Are the Current Account Imbalances between EMU Countries Sustainable? Evidence from Parametric and Non-Parametric Tests

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Abstract

Using parametric and non-parametric estimation techniques, we analyze the sustainability of the recently growing current account imbalances in the Euro Area and test whether the introduction of the European Monetary Union has aggravated these imbalances. For these purposes two alternative criteria for the assessment of external debt sustainability are considered: One based on intertemporal budget constraints as proposed by Bohn (1998), and the other based on the stationarity properties of the stochastic process of the debt-to-GDP ratio. The Bohn test is applied using the pooled mean-group estimator proposed by Pesaran and Smith (1995). Mean reversion is analyzed by the Breitung panel unit root test. Variants of both test procedures with time varying coefficients using penalized splines estimation are performed. We find empirical evidence suggesting that the introduction of the EMU is associated with a regime shift from sustainability to unsustainability of external debt accumulation among the Euro countries considered.

Keywords: current account, external debt, imbalances, sustainability, EMU, non-parametric techniques

JEL Classification: F32, F34, F42, C14

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1 Introduction

In recent years the size and persistence of trade deficits in Euro Area countries such as Italy, Spain, Portugal and Greece has led to a significant rise in their external debt. At the same time, other European countries such as Germany, France and Finland have managed to run persistent current account surpluses and to accumulate positive net assets. Given the extent of these developments, a question naturally arises. How should these current account imbalances in the EMU countries be assessed?

As pointed out by Blanchard and Giavazzi (2002) and Blanchard (2007), the establishment of the EMU may have contributed to the integration of European capital markets allowing domestic agents to get easier access to international funds. Following this argument, the growing current account imbalances among EMU countries would be the consequence of optimizing individual behavior and could, therefore, be considered as sustainable if they are consistent with the transversality condition (TC). There are however other mechanisms – most of them related to the flexibility of the real exchange channel – which may have led to the rise of current account imbalances in the Euro Area but may not necessarily be consistent with optimizing behavior and with the above notion of sustainability. On the one hand, as already pointed out by Friedman (1953), since flexible exchange rates accelerate the speed of current account adjustment, the abolition of country-specific nominal exchange rates may have led to a significant decrease in the real exchange rate flexibility in the Euro Area. Rigidities in the adjustment of unit labor costs, as well as a centralized monetary policy with an inflation target of 2% may have also contributed to such a development. Further, since an external debt process considered as unsustainable cannot be optimal, the question of external debt sustainability is directly linked to the question to what extent endogenous macroeconomic adjustment processes can manage to balance current accounts in the long run. Furthermore, this issue is crucial for economic policy making as changes in the policy setting may be required if the divergent accumulation of external debt proves unsustainable.

Along the lines of Bohn’s (1995, 1998) analysis of fiscal debt sustainability, we derive from a small-scale stochastic model of intertemporal trade a simple testable sufficient (but not necessary) condition for the TC to hold: the response of the net exports to a one-unit

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1Lane and Milesi-Ferretti (2007a) and Schmitz and von Hagen (2009) find empirical evidence for a substantial integration of the financial markets among EMU countries.

2Given the low labor mobility existing among the majority of European countries (cf. Bertola 2000), the real exchange rate channel is a central macroeconomic adjustment mechanism to external imbalances in these countries.

3The link between exchange rate flexibility and the speed of current account adjustments has been supported empirically by Ghosh et al. (2010) and, for the Euro Area, by Berger and Nitsch (2010) as well as contested, among others, by Chinn and Wei (2008).
change in external debt has to be positive. We call the development of a net external debt-to-GDP ratio over time *sustainable* if it is consistent with this condition.\(^4\)

As shown by Bohn (2007), however, the transversality condition holds for any debt process which is integrated of finite order which makes this condition a very weak criteria for assessing debt sustainability. For this reason, we also use a more operational sustainability criterion which simply requires the external debt-to-GDP ratio to be mean reverting. Accordingly, we call a debt process *operationally sustainable* if it is stationary. This approach follows the suggestion of Bohn (2007) that unbounded debt expansion relative to GDP cannot be sustainable from a practical perspective. This operational definition of sustainability has two advantages: First, mean reversion is not only a sufficient but, in a general equilibrium setting, also a necessary condition for sustainability. Second, the autoregressive parameter measures the memory of the debt series and provides a measure of how fast the debt series returns to its mean.

Using parametric as well as non-parametric estimation techniques we test for sustainability and operational sustainability of external debt for ten European countries which joined the EMU right from the start from 1975 to 2009: Germany (DE), France (FR), Finland (FN), Belgium (BG), the Netherlands (NL), Austria (AT), Italy (IT), Spain (ES), Portugal (PT) and Greece (GR).\(^5\) Using an error correction specification we estimate the long-run response of the net exports-GDP ratio to the external debt-to-GDP ratio. To obtain robust results in the estimation of long-run relations for groups of countries and for sub-periods and highlight differences between countries with high and low external debt we use the pooled mean-group estimator proposed by Pesaran and Smith (1995) and Pesaran et al. (1999). This estimator is appealing for our purposes as it allows for flexibility regarding the specification of short-run dynamics. As a robustness check we estimate an ARDL model for the same country groups and sub-periods. To analyze the response coefficients with respect to changes in the real exchange rate flexibility we fit the data to a generalized additive model using a penalized spline estimator.

In order to assess the mean reverting propensity of the external debt-to-GDP ratio and to obtain the autoregressive coefficients, we perform Augmented Dickey-Fuller unit root tests for each country. Robustness is checked by the Elliot-Rothenberg-Stock (1996) and Zivot-Andrews (1992) unit root tests. Because of the low power of unit root tests and,

\(^4\)The Bohn test has two advantages over traditional debt sustainability tests pioneered by Hamilton and Flavin (1986), Wilcox (1989) and Trehan and Walsh (1991): First, it does not require an assumption about the correct discount rate. Second, it can be applied to stochastic economies in which dynamic efficiency is consistent with an interest rate below the growth rate of output.

\(^5\)All of them introduced the Euro in 1999, apart from Greece which followed in 2001. We exclude Ireland and Luxembourg from our sample due to lack of data. Moreover, Ireland’s exceptional position as a haven for financial industries may have distorted the results.
in order to analyze the processes for sub-periods, we perform the Breitung (2000) panel unit root test. To analyze the memory of the debt series with respect to changes in the real exchange rate flexibility, we use penalized spline estimation to obtain a time variant autoregressive term.

We find that, on average over all countries and the entire period analyzed, the external debt accumulation has been consistent with the TC. By splitting the sample, we find that current account adjustment mechanisms seem to have avoided persistent imbalances especially in the period prior to the implementation of the convergence criteria in 1997. Yet, in the period thereafter, the coefficient estimates do not allow us to confirm the validity of the TC. This indicates that the introduction of the Euro may have impeded some of the forces adjusting the current accounts. Further, we find empirical evidence for external debt sustainability over the entire sample period only for the surplus countries. Hence, our results do not confirm Blanchard and Giavazzi’s (2002) suggestion that the growing imbalances in the Euro Area are optimal.

The analysis of operational sustainability reveals similar results. The Breitung panel unit root test indicates stationarity of the debt series on average over the whole sample period. The same holds for the period before the EMU implementation. Thereafter the unit root hypothesis cannot be reject anymore indicating that the current accounts became operationally unsustainable. Here, the main culprits seem to be Italy, Spain, Portugal, Greece on the one hand and Germany on the other, all of whom exhibited external debt-to-GDP ratios which deviated strongly from the mean. While the unit root hypothesis cannot be rejected for a group comprising these countries, it can be rejected for the others.

The remainder of the paper proceeds as follows: Section 2 sketches a simple stochastic model of inter-temporal trade which allow us to derive a testable condition for external debt sustainability. It also motivates the concept of operational sustainability defined as mean reversion of the external debt-to-GDP process. Section 3 discusses the data used in this study. Section 4 performs the Bohn test in error correction specification using the pooled mean-group estimator as well as in ARDL form. We also provide evidence from non-parametric estimations of the response coefficient. Section 5 tests for operational sustainability by performing unit root tests for single countries and groups as well as by non-parametric estimations of the autoregressive coefficient. Section 6 concludes by discussing some policy implications resulting from our empirical findings.

2 The theoretical framework

In the following we set up an intertemporal stochastic model of international trade which we use in the next section to derive the conditions which make an external debt process
sustainable from a theoretical point of view. Our model is in the spirit of Bohn (1995), where the conditions for government debt sustainability in a closed economy have been studied.

Let there be two symmetric open economies – a home country and a foreign country – each populated by an infinitely lived representative agent. Although considering only two countries, we suppose complete international asset markets, i.e., there is a market for insuring any kind of risk. Using the notation of Obstfeld and Rogoff (1996, pp. 340-3), the state of the world in period $t$ and the history of realized states up to $t$ are represented by $s_t$ and $h_t$, respectively, with $s_t \in S(h_{t-1})$ and $h_t \in H_t$. We suppose a discrete probability distribution of the states.

Each period, the representative agent of the home country receives $Y_t$ units of the good as income which can be used for consumption or trading in risky assets with the agent of the foreign country. We assume the stream of income to have a finite present value. A consumption path through the sets of time and states is chosen in order to maximize expected utility according to

$$V_t = \sum_{t=0}^{\infty} \beta^t \sum_{h_t \in H_t} \pi(h_t) U(C(h_t))$$  \hspace{1cm} (1)

$$s.t. \quad A_t(h_t) + Y_t(h_t) = C_t(h_t) + \sum_{s_{t+1} \in S_{t+1}} Q(s_{t+1} \mid h_t) A(s_{t+1} \mid h_t)$$  \hspace{1cm} (2)

for all $h_t \in H_t$ and for all $t$. $\beta > 0$ and $U(\cdot)$ is strictly increasing and concave. $\pi(h_t)$ is the probability of the event $h_t$. $Q(s_{t+n} \mid h_t)$ is the period $t$ world-market price of an Arrow-Debreu security, $A(s_{t+n})$, that yields one unit of the consumption good in state $s_{t+n}$ at $t+n$ and zero units otherwise. Equation (2) is the budget constraint in time $t$ with realized history $h_t$. It constrains current consumption and the purchase of contingent claims for the next period by the value of current assets and output. The optimization problem of the agent in the foreign country is equivalent.

If both economies considered move along an optimal consumption path an initial stock of external debt from one country cannot be rolled over infinitely in expense of the other one, i.e., Ponzi-Schemes are ruled out. This condition is given by

$$\lim_{N \to \infty} \sum_{h_{t+N} \in H_{t+N}} Q(h_{t+N} \mid h_t) B(h_{t+N} \mid h_t) = 0$$  \hspace{1cm} (3)

where $B(h_t) = -A(h_t)$. It states, loosely speaking, that the value of the contingent claim to be enforced in the limit in terms of period $t$’s consumption good must be zero. The intuition why it follows from intertemporal optimization is straightforward. Suppose the left hand side in (3) exceeds zero for the home country, i.e., it runs a Ponzi-Game against
the foreign country. Then the foreign investor cannot be on an optimal path as a slight expansion of consumption through time and state by selling contingent claims to the home country could improve his or her expected utility. The equivalent holds in the reverse case. An external debt policy which is consistent with the *No-Ponzi-Game* condition (NPC) in (3) shall be referred to as *sustainable* in the following.

A home country’s debt policy may violate sustainability in two ways: the left hand side of (3) can go either beyond zero or below zero. Yet, only in case of a violation of the former type a country’s accumulation of external debt is traditionally perceived as unsustainable. As becomes clear in the general equilibrium setting, however, asset accumulation consistent with a violation of the latter type is also unsustainable in the sense that, as a compensation, there need to be at least one country running a Ponzi-Game against the surplus country.

The first-order condition of the optimization problem in (1) and (2) implies

\[ Q(h_{t+N} | h_t) = \pi(h_{t+N} | h_t)u_{t,n} \]  \hspace{1cm} (4)

with \( u_{t,n} \) being the stochastic discount factor defined as

\[ u_{t,n} = \beta^n \frac{U'(Y(h_{t+N} | h_t) - NX(h_{t+N} | h_t))}{U'(Y(h_t) - NX(h_t))} \]  \hspace{1cm} (5)

where \( NX_t = Y_t - C_t \) denotes net exports. Substituting (4) into (3), applying the expectations operator and noting that \( \sum_{h_{t+N} \in H_{t+N}} \pi(h_{t+N} | h_t) = 1 \) the NPC can be rewritten as the *transversality condition* (TC),

\[ \lim_{N \to \infty} E_t[u_{t,N}B(h_{t+N} | h_t)] = 0 \]  \hspace{1cm} (6)

Recalling \( B(h_t) = -A(h_t) \) and applying the expectations operator, we can derive the *inter-temporal budget constraint* (IBC) for the stochastic open economy from (2) and (3) as

\[ B_t = \sum_{n \geq 0} E_t[u_{t,n}NX(h_{t+N} | h_t)]. \]  \hspace{1cm} (7)

Note that, we have not imposed any restriction on the discount factor, \( u_{t,n} \). As argued by Bohn (1995), setting up the TC and the IBC within a general stochastic framework allows us to derive an econometric test outlined by Bohn (1998) which has the following advantages over tests derived from deterministic economies (cf. Hamilton and Flavin 1986; Wilcox 1989; Trehan and Walsh 1991): First, the test can be applied to countries whose long-term interest rate for external debt falls short of the growth rate of GDP – a phenomenon inconsistent with *dynamic efficiency* for deterministic economies but not for stochastic economies. Second, traditional tests of debt sustainability need to
make an assumption about the discount rate which usually has been approximated by (the average of) a safe long-term interest rate. As shown by Bohn (1998), however, this may not be a theoretically sound practice as there is no straightforward relationship between $u_{t,n}$ and an observed interest rate.\(^6\) Hence, we follow Bohn (1998) and derive a general criteria and test of sustainability also applicable in stochastic economies.

2.1 A theory-based definition of external debt sustainability

Recalling $B(h_t) = -A(h_t)$, using $\sum_{s_{t+1} \in S_{t+1}} Q(s_{t+1} | h_t)(1 + R(s_{t+1} | h_t)) = 1$ resulting from the Euler equations where $R(s_{t+1} | h_t)$ is the return of an asset in state $s_{t+1}$, dividing by $Y_t$ and dropping the state and history indices for notational convenience, the budget identity (2) can be rewritten as

$$b_{t+1} = \frac{1 + R_{t+1}}{1 + \gamma_{t+1}}(b_t - n_x_t)$$

(8)

where $\gamma_t$ is the growth rate of output from $t-1$ to $t$. In the spirit of Bohn (1998) we suppose there is a linear relationship between a country’s net exports and its stock of external debt of the form

$$n_x_t = \varrho b_t + \mu_t$$

(9)

where $n_x_t$ and $b_t$ are net exports and external debt, respectively, both normalized by GDP. $\varrho$ is a parameter and $\mu_t$ a stochastic process. Substituting (9) into (8) and iterating forward, we get

$$b_{t+n} = (1 - \varrho)^n \prod_{k=1}^{n} \frac{1 + R_{t+k}}{1 + \gamma_{t+k}} b_t - \sum_{l=1}^{n} (1 - \varrho)^{n-l} \prod_{k=1}^{n} \frac{1 + R_{t+k}}{1 + \gamma_{t+k}} \mu_{t+l-1}$$

(10)

\(^6\) The theoretical conditions underlying sustainability tests for deterministic economies are derived as follows: Let $r_{t,n}$ denote the interest rate on a safe security issued at time $t$ that yields one unit of the consumption good $n$ periods ahead regardless of the state of nature. Then, the no-arbitrage condition implies that $E_t[u_{t,n}] = (1 + r_{t,n})^{-n}$. Substituting this term into the TC in (6) yields

$$\lim_{N \to \infty} \left\{ (1 + r_{t,N})^{-N} E_t[B(h_{t+N} | h_t)] + \text{Cov}_t[u_{t,N}, B(h_{t+N} | h_t)] \right\} = 0$$

Assuming our agents to be risk neutral, the pricing kernel in (5) collapses to the constant time preference, i.e. $u_{t,n} = \beta^n$. It also implies that $\beta = (1 + r)^{-1}$. The covariance terms in the equation above drop out and we can rewrite the TC and IBC as

$$\lim_{N \to \infty} (1 + r)^{-N} E_t[B_{t+N}] = 0$$

$$B_t = \sum_{k=0}^{\infty} (1 + r)^{-k} E_t[NX_{t+k}]$$
Using the straightforward relationships $b_t = \frac{B_t}{Y_t}$ and $Y_{t+n} = \prod_{k=1}^{n}(1 + \gamma_{t+k})Y_t$ as well as the result of the Euler equations which apply to all financial claims that $E_t[u_{t,n} \prod_{k=1}^{n}(1 + R_{t+k})] = 1$, substituting (10) into the TC in (6) and re-arranging yields

$$\lim_{N \to \infty} (1 - \theta)^N b_t - \sum_{i=1}^{N} (1 - \theta)^{N-i} E_t[u_{t,i} \prod_{k=1}^{i-1}(1 + \gamma_{t+k})\mu_{t+i-1}] = 0$$

where we drop the history index for simplicity. The assumption of a finite present value of all future income, $\lim_{N \to \infty} Y_t \sum_{i=1}^{N} E_t[u_{t,i} \prod_{k=1}^{i-1}(1 + \gamma_{t+k})]$, requires that each summand converges to zero. This implies for (11) that the second term equals zero in the limit leading to

$$\lim_{N \to \infty} (1 - \theta)^N b_t = 0$$

To have a positive initial stock of debt converging to zero in present value terms, $\theta > 0$. This is a sufficient condition for the debt process to be sustainable.\(^7\)

As shown by Canzoneri et al. (2001) and argued – in the context of the analysis of government debt – by Bohn (2005), a time-variant $\theta_t$ implies sustainability if $\theta_t \geq 0 \ \forall \ t$ and $\theta_t > 0$ holds infinitely often.

### 2.2 An operational definition of external debt sustainability

In the previous section, we derived a sufficient condition ($\theta > 0$) for a debt process to be sustainable in the sense that the TC and IBC hold. However, for policy purposes this definition of sustainability may be suitable only to a limited extent because of two shortcomings:

First, the validity of the TC is a very weak definition of sustainability as a broad range of debt processes are consistent with it. In fact, as shown by Bohn (2007), any debt series which is integrated of finite order is consistent with the TC.\(^8\) Hence, a positive reaction coefficient, $\theta$, implies the validity of the TC, even if debt-to-GDP process is unbounded. For this reason, Bohn (2007) suggests to impose stronger conditions for a debt accumulation process to be sustainable, such as boundedness of the debt-to-GDP ratio.\(^9\)

\(^7\) A formal proof of the proposition that a positive $\theta$ is a sufficient condition for the TC and IBC to hold is provided in the unpublished appendix of Bohn (1998).

\(^8\) Consider the TC for a deterministic economy, $\lim_{N \to \infty}(1+r)^{-N}E_t[B_{t+N}] = 0$, and suppose $B_t \sim I(m)$ with $m$ being finite. One can show that the exponential term $(1+r)^{-t}$ decreases faster with $t$ than the $m$-th order polynomial $B_t$ increases. Hence, the discounted expected stock of debt will asymptotically always converge to zero in this case.

\(^9\) In particular, Bohn (2007) suggests to interpret the size of the response coefficient, $\theta$. Assuming a constant saw interest rate, $R$, and a constant GDP growth rate, $\gamma$, $\theta > R - \gamma$ implies the debt-to-GDP...
Second, the Bohn test, unfortunately, can only test for a violation of the TC by which a country runs a Ponzi-Game against the rest of the world. Hence, an unbounded accumulation of net external assets is consistent with the traditional definition of sustainability. However, in a closed economic system accounting implies that one’s assets are someone else’s liabilities. Thus, a sustainability test should be able to take growing imbalances into account, especially if one is interested in the adjustment speed by which imbalances are abolished.

Hence, from a practical policy perspective, an operational criteria for the sustainability of an external debt-to-GDP process should reject sustainability in the following two cases: first, if a country’s external debt-to-GDP ratio rises without bounds and, second, if a decreasing external debt-to-GDP ratio, i.e. rising net assets relative to GDP, is necessarily associated with an unbounded expansion of the debt-to-GDP ratio in another country. In practice, a sustainable net external debt-to-GDP ratio should be mean-reverting. Hence, we consider an external debt-to-GDP process as operationally sustainable if it can be categorized as a covariance-stationary process.\(^{10}\)

The conditions under which an unbounded expansion of assets relative to GDP in one country implies an unbounded expansion of liabilities relative to GDP in another are not obvious. To clarify this, let us consider a stylized open economic area consisting of countries trading with each other and with the rest of the world. We assume the interest rate on international assets to be zero and abstract from capital flows. Let \(b_i^t\) denote the external debt-to-GDP ratio of any country \(i\) in period \(t\) with external debt being the cumulated negative net exports. \(x_t \sim I(k)\) stands for the process \(x_t\) to be integrated of order \(k\). Then, the following holds:

**Proposition 1.** Let \(A\) and \(B\) denote two random countries of an open economic area and let \(\mathcal{C}\) denote the set of all countries of this area different from \(A\) and \(B\). Suppose that the growth rate of GDP is equal across all countries of the economic area and that each country’s share of exports to the rest of the world is constant and equal to its share of imports from the rest of the world. Suppose further that \(b_i^t \sim I(0)\) for all countries \(i \in \mathcal{C}\). Then, \(b_i^A \sim I(0)\) if and only if \(b_i^B \sim I(0)\).

**Proof.** See appendix. \(\square\)

\(^{10}\)Note that the property of mean-reversion is weaker than covariance stationarity as the former does not require time-invariant autocovariances. Yet, unit root testing procedures test against the hypothesis of covariance stationarity which is the reason why we impose the stronger restriction on an operationally sustainable debt-to-GDP process.
In an open economy, the symmetry between unbounded asset and debt accumulation normalized by GDP is established if the growth rates of GDP are equal across countries and each country’s shares of outside exports and outside imports are equal and constant. These conditions are met by the EMU only to some extent. Yet, making these conditions transparent allows us to qualify our empirical results in the context of deviations. Slight discrepancies may still be sufficient, as the conditions are only sufficient and not necessary. As we will argue in the empirical section, in the context of the EMU, only the assumption of synchronous GDP growth requires some caution when interpreting the results.

From a policy perspective, our operational criteria of debt sustainability has high economic significance as suggested by the following observations: First, even if an unbounded debt-to-GDP process is consistent with the TC, the prediction that lenders will maintain the flow of credit is implausible. As there are limits to export capacities, bounds on sustainable debt-to-GDP ratios which go beyond the requirements imposed by the TC may be of economic interest (Bohn 2007). Second, financial markets do not seem to be very sensitive towards the level of external debt-to-GDP ratios which were often inherited from times before the liberalization of international capital flows. They respond primarily to changes of those ratios. Third, in the equivalent case of sovereign debt, the Maastricht criteria require a debt-to-GDP ratio of below 60%, a level which enjoys high political and economic attention but is definitely a much stronger restriction on the debt-to-GDP process than the TC.

In the following we assume the debt-to-GDP process, $b_t$, to follow an AR(1) process of the form

$$b_t = \bar{b} + \rho b_{t-1} + \eta_t$$

(13)

where $\bar{b}$ is an external debt-to-GDP ratio $\bar{b}$ which is perceived as a long-run equilibrium position of the economy. $\eta_t$ is a disturbance term. Operational sustainability holds if $\rho < 1$, i.e the debt-to-GDP ratio is mean reverting. This parameter measures the memory of the debt series and tells us how long it takes the debt series to return to $\bar{b}$.

3 Data and some stylized facts

For all countries considered, we used quarterly data on net exports, net foreign liabilities, the GDP, domestic demand as a share of total OECD demand, the real effective exchange rate index based on consumer prices as well as the unit labor cost index.\footnote{The weights for computing the real effective exchange rate are determined according to the volume traded bilaterally with EU-12 countries.} The data cover the period from 1974:1 to 2009:4. Quarterly data on net exports, GDP and relative...
domestic demand were obtained from the OECD economic outlook database, exchange rate and unit labor cost data from Eurostat. The series on net foreign liabilities were taken from the updated and extended version of the External Wealth of Nations Mark II database developed by Lane and Milesi-Ferretti (2007b) who provide a comprehensive dataset on net external debt which draws from different sources, in particular from national statistics about a country’s international investment position. Since these data is available only at an annual frequency, to compute a quarterly series we employed the Chow and Lin (1971) procedure to interpolate the annual series by using variations in the quarterly series on the accumulated current account which, in the short run, is a reasonable approximation of net foreign debt.\footnote{All R programs can be obtained from the authors upon request.}

Figure 1 presents the net exports-output ratio, \( nx_t \), and the external debt-output ratio \( b_t \) for all countries investigated. Over the last 15 years, while Germany, France and Belgium managed to accumulate positive stocks of net assets in this time, the reverse picture hold for the Southern countries, i.e. Italy, Spain, Portugal and Greece. These countries started to accumulate large amounts of external debt since the mid-1990s. Whether these growing imbalances are sustainable will be discussed in the next two sections.

4 Sustainability and external debt accumulation in the EMU-10

4.1 Panel estimations

As discussed in the previous section, an external debt-to-GDP process is sustainable if the parameter \( \varrho \) in the linear relation between \( nx_t \) and \( b_t \) given in (9) is positive. Similarly, Bohn (2007) showed for fiscal as well as for external deficits that an error-correction relationship between the surplus-to-GDP process and the debt-to-GDP process with a long-term coefficient \( \varrho > 0 \) and \( \varrho \in (0, 1 + \rho) \) implies that the TC holds.\footnote{As widely known, if both processes are non-stationary but a linear combination \( (\mu_t) \) of the two is stationary, a cointegration relationship exists and the OLS estimate for \( \varrho \) is super-consistent.}

Including an index for country \( i \) and lags of order \( p \) and \( q \) for \( b_{t,i} \) with parameters \( \theta_{i,k} \) for \( k = 0, \ldots, p \) and for \( nx_{i,t} \) with parameters \( \psi_{i,k} \) for \( k = 1, \ldots, q \), respectively, we thus reformulate (9) through the following error correction specification

\[
x_{i,t} = \alpha_i + \sum_{k=0}^{p} \theta_{i,k} b_{i,t-k} + \sum_{k=1}^{q} \psi_{i,k} nx_{i,t-k} + \varepsilon_{i,t}, \tag{14}
\]

where \( \alpha_i + \sum_{k=1}^{p} \theta_{i,k} b_{i,t-k} + \sum_{k=1}^{q} \psi_{i,k} nx_{i,t-k} + \varepsilon_{i,t} = \mu_{i,t} \varepsilon_{i,t} \) is an i.i.d disturbance term.
Figure 1: The net external debt-to-GDP ratio (bars, right axis) and the net exports-to-GDP ratio (solid line, left axis) for ten European countries from 1974:1 to 2009:4
with mean zero. Some manipulation yields

\[ \Delta n_{x_t} = \alpha_i + \phi_i (n_{x_{t-1}} - \theta_i b_{t-1}) + \sum_{k=0}^{p-1} \theta^i_{i,k} \Delta b_{i,t-k} + \sum_{k=1}^{q-1} \psi^i_{i,k} \Delta n_{x_{i,t-k}} + \varepsilon_{i,t} \]  

(15)

where \( \theta^i_{i,k} = -\sum_{j=k+1}^{p} \theta_{i,j} \) and \( \psi^i_{i,k} = -\sum_{j=k+1}^{q} \psi_{i,j} \). The parameter \( \theta_i = -\phi_i^{-1} \sum_{k=0}^{p} \theta_{i,k} \) is the long-run relationship between \( n_{x_t} \) and \( b_t \) where \( \phi_i = -(1 - \sum_{k=1}^{q} \psi_{i,k}) \) measures the speed of adjustment of \( n_{x_t} \) after a change in \( b_t \).

Given the low number of observations available for each country, we follow a panel estimation approach which pools heterogeneous groups but allows for flexibility in the specification of the short-run dynamics. Since we are interested in the average response of \( n_{x_t} \) to a change in \( b_t \), two alternative estimation techniques seem appropriate: the mean-group (MP) estimator and the pooled mean-group (PMP) estimator suggested by Pesaran and Smith (1995) and Pesaran et al. (1999), respectively. The former estimates independent ECMs for each group and computes the mean of the group-specific coefficients and statistics. However, the MP estimator is inefficient if the error-correction coefficients such as \( \theta_i \) are the same across countries. In such a case, the PMP estimator, which restricts \( \theta_i = \theta \forall i \) but allows other parameters and statistics to vary across countries, is preferable. Since Hausman tests indicated superiority of the PMP estimator in (almost) all estimations, we only report these results.\(^\text{14}\)

Column (a) in table 1 reports the results for an estimation of (15) including all countries over the entire period considered. Note that the speed of adjustment coefficients in table 1 always exhibit the correct negative sign and are almost always significant at the 90% confidence level. This implies that there seems to exist a cointegrated relationship between \( n_{x_t} \) and \( b_t \). More specifically, we find a significant common long-run response coefficient, \( \theta \), of 0.02 and a speed of adjustment coefficient of 0.10 in absolute terms. The latter implies an average half-life of roughly 7 quarters.\(^\text{15}\) The half-life implied by our estimates is consistent with the findings of Duru et al. (2010) who analyze a large panel of industrialized and emerging market economies and also estimate a half-life of 7 quarters. They find a long-run response coefficient of 0.07 and a speed of adjustment coefficient of 0.31 using annual data.

An interesting question we are able to discuss is whether the introduction of the convergence criteria in 1997 is associated with a change in the long-run responsiveness of net exports to a change in the stock of external debt. The parameter estimates for the two sub-periods are reported in column (b). As these two estimations show, the average long-run response coefficient decreased tremendously from 0.16 to -0.03. Also the speed of

\(^{14}\)For each estimation the lag order has been selected according to the BIC with a maximum of 4 in each variable.

\(^{15}\)The half-life is computed by \( \frac{\ln(0.5)}{\ln(1-|\theta|)} \).
Table 1: Pooled mean group estimation of the long-run response of the net exports-to-GDP ratio to a change in the net external debt-to-GDP ratio for various subsamples

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$\hat{\theta}$</td>
<td>0.021**</td>
<td>0.153***</td>
<td>-0.026***</td>
<td>0.084***</td>
<td>0.010</td>
</tr>
<tr>
<td>$\hat{\phi}$</td>
<td>(0.009)</td>
<td>(0.031)</td>
<td>(0.005)</td>
<td>(0.019)</td>
<td>(0.010)</td>
</tr>
<tr>
<td>$\hat{\psi}$</td>
<td>-0.100***</td>
<td>-0.119***</td>
<td>-0.088*</td>
<td>-0.083*</td>
<td>-0.129***</td>
</tr>
<tr>
<td># of obs.</td>
<td>1354</td>
<td>866</td>
<td>488</td>
<td>816</td>
<td>536</td>
</tr>
</tbody>
</table>

Notes: $\hat{\theta}$ and $\hat{\phi}$ denote the long-run coefficient and the error-correction coefficient, respectively. Standard errors are in parenthesis. *, **, and *** denote the significance level at 10%, 5%, and 1%, respectively.

adjustment coefficient slightly decreased in absolute terms. This is a striking finding and strongly suggests that the current setting of the currency union may have impeded the adjustment of trade accounts in the analyzed European countries.

Column (c) compares the average adjustment in northern and southern countries.\textsuperscript{16} As indicated in figure 1 the latter group tends to have a more pronounced expansion of debt over time than the latter. Over the whole period the average long-run response coefficient is 0.08 in the North which is significantly different from zero at the 1% level. Yet, in the South, no significant adjustment of the trade balance to increasing external debt can be found. Columns (d) and (e) report the estimates for North and South before and after the introduction of the EMU. The speed of adjustment appears to decrease in both economic regions. Yet, the responsiveness of net exports to changes in debt dropped enormously in both. Before the EMU, $\varrho$ was relatively high in both regions (0.16 and 0.06) and low thereafter (-0.03 and 0.01).

In order to check the robustness of these results the ARDL model in (14) was also

\textsuperscript{16} The North includes Germany, France, Finland, Belgium, the Netherlands and Austria; the South includes Italy, Spain, Portugal and Greece.
Table 2: Dynamic ARDL panel estimation of the long-run response of the net exports-to-GDP ratio to a change in the net external debt-to-GDP ratio for various subsamples

<table>
<thead>
<tr>
<th></th>
<th>(a)</th>
<th>(b)</th>
<th>(c)</th>
<th>(d)</th>
<th>(e)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All countries</td>
<td>All countries</td>
<td>North</td>
<td>South</td>
<td></td>
</tr>
<tr>
<td>(\hat{\rho})</td>
<td>0.044**</td>
<td>0.113***</td>
<td>0.047**</td>
<td>0.061**</td>
<td>-0.011</td>
</tr>
<tr>
<td></td>
<td>(5.40)</td>
<td>(12.95)</td>
<td>(6.12)</td>
<td>(3.86)</td>
<td>(0.43)</td>
</tr>
<tr>
<td># of obs.</td>
<td>1348</td>
<td>860</td>
<td>488</td>
<td>806</td>
<td>524</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>North</td>
<td>South</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\hat{\rho})</td>
<td>0.128***</td>
<td>0.052**</td>
<td>0.092**</td>
<td>0.024</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(8.37)</td>
<td>(4.81)</td>
<td>(4.16)</td>
<td>(0.29)</td>
<td></td>
</tr>
<tr>
<td># of obs.</td>
<td>530</td>
<td>296</td>
<td>340</td>
<td>192</td>
<td></td>
</tr>
</tbody>
</table>

Notes: \(\hat{\rho}\) is the long-run coefficient computed by \(\hat{\rho} = \frac{\sum_{k=1}^{p} \hat{\theta}_k}{1-\sum_{k=1}^{p} \psi_k}\). The lag order \(p\) has been chosen in the following way: starting from 2 increase \(p\) as long as the Breusch-Godfrey/Woolridge test for serial correlation in panel models rejects any of the null hypotheses of autocorrelation of order 1 to 3. The lag structures are reported in brackets. The significance of \(\rho\) has been tested using a Wald-type test of non-linear restrictions. **, ***, and **** denote the significance level at 10%, 5%, and 1%, respectively.

estimated for the same panels of countries after a within transformation to remove country specific effects.\(^{17}\) We assume the same lag length for \(nx_t\) and \(b_t\), i.e. \(p = q\). The lag order \(p\) has been determined by an iterative procedure.\(^{18}\) By eliminating serial correlation we ensure the estimator to be consistent. Table 2 reports the long-run coefficient, \(\hat{\rho} = \frac{\sum_{k=1}^{p} \hat{\theta}_k}{1-\sum_{k=1}^{p} \psi_k}\), for each of the panels considered. To determine the significance level of the long-run coefficient, we applied a Wald test on non-linear restrictions.

The estimates of the long-run coefficient \(\rho\) confirm the results of the ECM above, showing especially that before 1997 the responsiveness of net exports to external debt was high; thereafter it dropped sharply. Yet, it is still significantly positive in contrast to the

\(^{17}\) Note that the downward bias of the estimates due the inclusion of the lagged dependent variable as a regressor is negligible since the number of observations along the time dimension, \(T\), is large in all the samples considered here. Attempts to estimate (14) by the linear GMM approach suggested by Arellano and Bond (1991) and Blundell and Bond (1998) which is the appropriate estimation technique for dynamic panels with small \(T\) failed due to insufficient computational resources given the large \(T\) of our sample.

\(^{18}\) Starting from a minimum of 2, we kept adding lags as long as the Breusch-Godfrey/Woolridge test for serial correlation in panel models rejected any of the null hypotheses of autocorrelation of order 1 to 3 at the 10% significance level. For the maximum lag length, we obtained 5.
finding of the ECM. Again we find evidence that the accumulation of external debt over the whole sample period was sustainable only for the North, but not for the South. In both the North and South, $\varrho$ appears to be significantly positive prior to the EMU and almost zero thereafter.

### 4.2 Varying-coefficients estimation

Structural breaks such as the introduction of the convergence criteria may cause the response of net exports to a change in the external debt-to-GDP ratio to vary over time. Non-parametric estimation techniques allow us to estimate time varying response coefficients. For this task, we follow Greiner et al. (2005) and use a simplified version of the model in (14) which relates the net exports-GDP ratio to the first lag of the external debt-to-GDP ratio. Specifying this as a generalized additive model with an identity link, we get

$$n_{x,t} = \alpha_i + f_i(z)\varrho_{i,t-1} + \gamma_i \bar{x}_{i,t-1} + \delta_i \varepsilon_{i,t-1} + \lambda_i w_{i,t-1} + \varepsilon_t$$  \hspace{1cm} (16)

where $f_i(\cdot)$ is a smooth function of the covariate $z$. As control variables we include in the regression $\bar{x}_{i,t}$, $\varepsilon_{i,t}$ and $w_{i,t}$ which denote domestic demand as a share of total demand in the OECD, the real effective exchange rate based on consumer prices and the index for unit labor costs, respectively.\(^19\)

As smooth functions we use plate regression splines which have the advantage of determining the knot locations, which are the points where the parts of the spline base connect to form a twice differentiable smooth function, endogenously (cf. Wood 2006). To estimate the form of $f_i(\cdot)$ we use penalized least squares. The intuition behind this estimator is the following: given the trade-off between explaining a high share of the variance in the data and the smoothness of $f(\cdot)$, a function $f(\cdot)$ which is optimal for a given smoothness parameter reflecting the weights of this trade-off is chosen. The smoothness parameter is determined endogenously by minimizing the Generalized Cross Validation criteria (cf. Hastie and Tibshirani 1990).

Defining, for example, $\varrho_{i,t} = f_i(t)\varrho_i$, we can interpret the smoothing function as a time varying coefficient. Such a specification, however, is likely to answer only partially the question of whether the implementation of the Maastricht convergence criteria, and finally the introduction of the Euro, may have aggravated the current account imbalances of the Euro Area countries.\(^20\)

\(^19\) These variables are commonly used in the empirical literature on the determinants of current accounts. See, among others, Argyrou and Chortareas (2008).

\(^20\) Indeed, regressions using such a specification do not deliver robust interpretable results.
Figure 2: The real effective exchange index rate based on the CPI for Northern and Southern European countries from 1974:1 to 2009:4

Indeed, as illustrated in figure 2, the real exchange rate volatility decreased enormously for the North and the South after the introduction of the Maastricht criteria in 1997, at around the same time where the current account imbalances in the EMU countries started to rise. This suggests that an important adjustment mechanism may have been impeded by the introduction of the Euro.

In particular, we are interested in the relationship between the speed of adjustment of external imbalances and real exchange rate flexibility. Hence, we use a smoothing function \( f_i(\cdot) \) in the exchange rate volatility and estimate the regression

\[

nx_{i,t} = \alpha_i + f_i(v_{i,t}) + \gamma_i x_{i,t-1} + \delta_i e_{i,t-1} + \lambda_i w_{i,t-1} + \varepsilon_t

\]

(17)

where \( v_{i,t} \) is the volatility of the exchange rate which we take as a proxy for the flexibility of the real exchange rate regime.\(^{21}\) Indeed, if the introduction of the Euro aggravated the

\(^{21}\)The volatility measure is computed by employing an HP-filter on the 9-quarter, 2-sided rolling standard deviation of the real effective exchange rate based on the CPI.
current account imbalances through impeding the real exchange rate mechanism, then one would expect a positive relation between $\varrho$ and the flexibility of the real exchange rate which has been reduced tremendously since the establishment of the EMU.\footnote{See figure 2.}

Figure 3 plots the relationship of $\varrho$ and $\nu$ for pooled estimations of the Northern and Southern countries.\footnote{We applied a within transformation of the data in order to eliminate fixed country effects. Since, there is no data available for the Greek relative domestic demand, we do not include Greece.} As it can be clearly observed, a negative relationship between the response of the net exports to the external debt-to-GDP ration seems to have prevailed in the North countries over the analyzed sample. In the North, the response coefficient seems thus to have increased, on average, with decreasing exchange rate flexibility resulting from the introduction of the Euro. Thus, the exchange rate mechanism does not seem to have been important for trade adjustment in these countries. We find the opposite for the South: the response coefficient decreased, on average, with decreasing exchange rate flexibility. Hence, the exchange rate mechanism seems to be more important for Southern than for Northern countries.

5 Operational sustainability and debt accumulation in the EMU-10

In this section, we test if the external debt accumulation in the Euro Area countries analyzed has been consistent with operational sustainability, i.e. if their external debt-to-GDP ratio featured a significant mean-reverting behavior over the analyzed period.

Since the external debt-to-GDP series are stationary after first-differencing for all coun-

\[ f(v(t))nx(t-1) \]

\[ v \]

\[ f(v(t))nx(t-1) \]

\[ v \]
tries considered, we restrict the set of admissible processes violating sustainability to I(1) processes. In case of a unit root, there are no forces driving the debt-to-GDP ratio back to a long-run mean. Rather, it moves through time without bounds. We test the hypothesis of a unit-root against the hypothesis of stationarity. The non-standard Dickey-Fuller distribution has to be applied to infer the significance of $\rho$ being different from unity in (13). Hence, we estimate a Dickey-Fuller equation of the form

$$\Delta b_{i,t} = \tilde{b}_i + (\rho - 1)b_{i,t-1} + \sum_{k=1}^{p_i} \theta_k \Delta b_{i,t-k} + \varepsilon_{i,t}. \quad (18)$$

The lagged values of the dependent variable have been included in order to avoid serial correlation in the residuals.

5.1 Country specific unit root tests

First we estimate (18) for each country. Table 3 reports the estimates for $\rho_i$ and the Dickey-Fuller statistic $\tau$ which lets us infer the significance by which we can reject the null that $b_{i,t}$ is a unit root process, i.e. $1 - \rho_i = 0$. The lag order $p_i$ has been selected automatically according to the AIC up to a maximum of 5.

Using the whole sample available, the autoregressive parameters are fairly close to 1 which is not surprising given the monthly frequency of our data. Averaging over the total period mostly yields coefficients which do not allow us to reject the unit-root hypothesis at the conventional 10% significance level. For any of the analyzed countries, except Finland, we do not find evidence strong enough to reject the unsustainability hypothesis, i.e. that the external debt-to-GDP ratios seem to have evolved in a non-mean reverting way in the analyzed period. This indicates that the evolution of external debt per GDP on average has not been sustainable according to our operational criteria for sustainability. For the period before the implementation of the convergence criteria we can reject the null of unsustainability for Austria and Spain. Thereafter, all series seem to exhibit a unit root.

Rather than considering only the significance levels of the parameters one may interpret, although with caution, the point estimates of $\rho_i$. For all southern countries, except Italy, $\rho_i$ rose from the first to the second period. For Italy, the parameter stayed almost unchanged. Also for Germany – which accumulated a tremendous amount of net foreign assets over the last decade – the debt series’s memory increased substantially during the EMU. In the other countries, $\rho_i$ decreased. It is worth to note, however, that the second period is substantially shorter than the first one which may bias the estimates for $\rho_i$ downwards in the second period. If we cut the sample in 1992:1 generating subsamples of equal size, $\rho_i$ increases substantially in the second period for all countries except France, Belgium and the Netherlands.
### Table 3: Augmented Dickey Fuller estimates of the external debt-to-GDP ratio

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\hat{\rho}_1$</td>
<td>$\tau$</td>
<td>$\hat{\rho}_1$</td>
</tr>
<tr>
<td>DE</td>
<td>1.007</td>
<td>0.53</td>
<td>0.978</td>
</tr>
<tr>
<td>FR</td>
<td>0.965</td>
<td>-1.67</td>
<td>0.957</td>
</tr>
<tr>
<td>FN</td>
<td>0.972</td>
<td>-2.84*</td>
<td>0.988</td>
</tr>
<tr>
<td>BG</td>
<td>0.993</td>
<td>-1.41</td>
<td>0.994</td>
</tr>
<tr>
<td>NL</td>
<td>0.983</td>
<td>-1.49</td>
<td>1.004</td>
</tr>
<tr>
<td>AT</td>
<td>0.974</td>
<td>-1.59</td>
<td>0.901</td>
</tr>
<tr>
<td>IT</td>
<td>0.993</td>
<td>-0.85</td>
<td>0.98</td>
</tr>
<tr>
<td>ES</td>
<td>0.990</td>
<td>1.59</td>
<td>0.871</td>
</tr>
<tr>
<td>PT</td>
<td>1.033</td>
<td>1.12</td>
<td>0.973</td>
</tr>
<tr>
<td>GR</td>
<td>0.996</td>
<td>-1.05</td>
<td>0.929</td>
</tr>
</tbody>
</table>

**Notes:** $\hat{\rho}_1$ is the estimated autoregressive parameter in (18) $\tau$ is the Dickey-Fuller test statistic. *, **, and *** denote the significance level at 10%, 5%, and 1%, respectively.

To check the robustness of the results on the persistence of each country’s debt-to-GDP series, we perform further tests over the total sample period as the power of unit roots tests are notoriously weak especially when applied to small samples. We additionally perform the Elliot-Rothenberg-Stock (ERS) test and the Zivot-Andrews (ZA) test on $b_t$. Table 4 reports the test results.

The following observations are worth to note: First, strong evidence for stationarity of the external debt-to-GDP series can only be found for Finland and the Netherlands. For the other countries most tests indicate a unit root. Second, although the ERS and ZA are not able to reject the null of a unit root for most countries, inspection of the test statistics reveals that the probability value is lower on average for Northern countries excluding Germany than for Southern countries including Germany. Third, the endogenously

---

24 The ADF test suffers under a small sample bias which arises due to the limited ability of OLS estimation to distinguish between a deterministic and a stochastic trend in case of high shock persistence. This is corrected for by the Elliot-Rothenberg-Stock (ERS) test. It utilizes an auxiliary regression to remove the constant and the deterministic trend from the time series which a simple ADF is then applied on. The lag length of the augmented term has been set equal to the respective lag length of the ADF tests above. Further, the power of unit root tests is even less strong at the presence of structural changes. To correct for this, we run the Zivot-Andrews (ZA) unit root test which builds on Perron (1989) test for structural change. In contrast to the latter, the former allows for an endogenous determination of the break point in the intercept. Recursively, regressions are run with dummies for changes in the intercept and/or trend moving from the beginning to the end of the sample. The specification which locates the structural change in a point where the trend-stationary alternative is most likely is chosen. Then, the Perron procedure with appropriate dummies is followed. In our context, the advantage of this approach is the endogenous determination of the potential break point which minimizes the problem of data mining.
Table 4: Elliot-Rothenberg-Stock unit root test and Zivot-Andrews unit root test of the external debt-to-GDP ratio

<table>
<thead>
<tr>
<th>Countries</th>
<th>ERS</th>
<th>ZA</th>
<th>break point</th>
</tr>
</thead>
<tbody>
<tr>
<td>DE</td>
<td>0.65</td>
<td>-2.54</td>
<td>2000:1</td>
</tr>
<tr>
<td>FR</td>
<td>-1.48</td>
<td>-2.91</td>
<td>1998:1</td>
</tr>
<tr>
<td>FN</td>
<td>-2.55**</td>
<td>-6.11***</td>
<td>1996:1</td>
</tr>
<tr>
<td>BG</td>
<td>-1.42</td>
<td>-2.79</td>
<td>1994:2</td>
</tr>
<tr>
<td>NL</td>
<td>-0.99</td>
<td>-5.44**</td>
<td>1992:1</td>
</tr>
<tr>
<td>AT</td>
<td>0.18</td>
<td>-4.52</td>
<td>1998:1</td>
</tr>
<tr>
<td>IT</td>
<td>0.14</td>
<td>-3.90</td>
<td>1992:3</td>
</tr>
<tr>
<td>ES</td>
<td>1.79</td>
<td>-2.79</td>
<td>1999:3</td>
</tr>
<tr>
<td>PT</td>
<td>0.44</td>
<td>-3.81</td>
<td>1984:1</td>
</tr>
<tr>
<td>GR</td>
<td>1.33</td>
<td>-3.33</td>
<td>1997:1</td>
</tr>
</tbody>
</table>

Notes: ERS is the Elliot-Rothenberg-Stock test statistic ZA is the Zivot-Andrews test statistic. Both test the null of a unit root against the alternative hypothesis of stationarity. The break point is estimated endogenously in the ZA test procedure. *, **, and *** denote the significance level at 10%, 5%, and 1%, respectively.

estimated break points mostly lie in the 1990s which is consistent with the hypothesis that the introduction of the EMU aggravated trade imbalances.

5.2 Panel unit root tests

Next we perform unit root tests for panels of countries. This is an especially useful exercise because of three reasons: First, the powers of unit root tests are notoriously weak when applied to small samples. Pooling countries raises the power of unit root tests and we might be able to reject the null for a group of countries. Second, it allows us to analyze the memory of the debt series for sub-periods and subsamples combined. Third, the assumption of a homogeneous \( \rho \) is not very restrictive in our context because all \( \rho \)'s are close to one. In particular we group countries with similar autoregressive coefficients, i.e. France, Finland, Belgium, Netherlands, Austria ("North w/o DE") vs. Germany, Italy, Spain, Portugal and Greece ("South w DE"). Note that the former group tends to operationally sustainable debt accumulation while the reverse holds for the latter group.

We estimate (18) employing the procedure by Breitung (2000) and Breitung and Das (2005). The test assumes that all panels have the same autoregressive term and tests the null hypothesis that all panels contain a unit root, i.e. \( \rho = 1 \), against the alternative that \( \rho < 1 \). The Breitung test is a modification of the Dickey-Fuller test by taking into account panel specific mean and trends which are eliminated by transforming the data.
Table 5: Breitung panel unit root test for the debt-to-GDP ratio

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>λ</td>
<td>-1.70</td>
<td>-1.70</td>
<td>-2.52</td>
<td>0.48</td>
</tr>
<tr>
<td># of obs.</td>
<td>1320</td>
<td>880</td>
<td>660</td>
<td>660</td>
</tr>
</tbody>
</table>

Notes: λ is the Breitung test statistic robust to cross-sectional correlation. The p-values are in curly brackets.

before computing the Dickey-Fuller regression. The standard Dickey-Fuller t-statistics apply. An advantage of the Breitung test is that it is robust to cross-sectional dependence.

The Breitung test assumes the data to follow an AR(1) process with a Dickey-Fuller representation of

$$\Delta b_{i,t} = \bar{b}_i + (\rho - 1)b_{i,t-1} + \varepsilon_{i,t}$$ \tag{19}$$

In case of n-th order process with $n > 1$, $\varepsilon_{i,t}$ is serially correlated. To make $\varepsilon_{i,t}$ i.i.d., a prewhitening procedure is applied which removes the autoregressive components of $b_{i,t}$ exceeding 1. This is achieved by substituting $\Delta b_{i,t}$ and $b_{i,t-1}$ by the residuals of two auxiliary regressions which relate $\Delta b_{i,t}$ and $b_{i,t-1}$ to the n first lags of $\Delta b_{i,t}$, respectively. In the subsequent analysis, we assume $b_t$ to be generated by an AR(3) process. Note that we exclude a time trend.

The test results are reported in table 5. Most strikingly, we can reject the null of a unit root at the 5% significance level for the panel including all countries and covering the whole sample period as indicated in column (a). The same holds for the period before the implementation of the EMU criteria (column (b)). Yet, for the period thereafter we cannot reject the unit root hypothesis at any reasonable level of significance. External debt accumulation seems thus to have become unsustainable on average in this second subperiod.

One immediate cause of this rising imbalance may be found in the Southern countries and Germany. Over the total period, the northern low debt-persistence countries seem to
exhibit a mean reverting average debt-to-GDP process as shown in column (c). The high
debt-persistence countries in the South including Germany, however, seem to have accu-
mulated debt and assets, respectively, without bounds as indicated by the test statistic’s
p-value of 0.684. More details are given in columns (d) and (e). Whereas the low-debt
persistence countries seem to have managed to stabilize imbalances in the era of the Euro,
apparently the high-external debt persistence countries we unable to keep a stable debt-
to-GDP ratio in that period. It is striking, however, that they were able to do so in the
pre-Euro era as indicated by a p-value of 0.044 which allows us to reject the null of a
common unit root.

Before proceeding with the discussion of our non-parametric estimation of operational
external-debt sustainability, we would like to qualify the above results in relation to Propo-
sition 1, where sufficient – but not necessary – conditions under which the symmetric con-
cept of operational sustainability is applicable in a stylized open economic area were stated.
More specifically, we want to briefly discuss how deviations from these conditions affect the
validity of the operational definition of sustainability. Thereby, we focus on Germany and
the Southern countries as one might suspect that there exists some extent of symmetry
between the former country’s asset and the latter countries’ debt accumulation.

The assumption of equal GDP growth rates across countries is required to avoid the time
series properties of the external debt-to-GDP ratios to be driven by diverging developments
of national GDPs. In fact, to some degree the observed imbalances between Germany and
the Southern countries are aggravated by slower GDP growth in the former than in the
latter. Between 1975 and 2007 the German nominal GDP measured in US-Dollars grew,
on average, by 1.64% per year whereas, for the four Southern countries, the corresponding
number is 2.32%.

The assumption that each country’s share of internal exports and imports are equal
ensures that the unbounded expansion of assets (liabilities) relative to GDP implies that
the share of these assets (liabilities) accumulated from internal trade also develop in an
unbounded way relative to GDP. Then, an unbounded asset-to-GDP ratio in one country
implies an unbounded debt-to-GDP ratio in another one and vice versa. Figure 4 plots the
shares of exports to and imports from the countries considered for Germany and the four
Southern countries from 1970 to 2009. In Germany, the shares of EMU exports and imports
have been very close over time. Therefore, Germany did not disproportionally accumulate
net assets from outside the Euro area. Also for the Southern countries (apart from Spain),
the assumption of equal internal export and import shares are not too far from reality.
Yet, the internal import share increased slightly relative to the internal export share from
the mid 1990s. Hence, to some extent, the Southern countries have accumulated net debt
increasingly from outside the EMU.

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Figure 4: The shares of exports to (solid line) and imports (dashed line) from the EMU countries considered for Germany, Italy, Spain, Portugal and Greece from 1970 to 2009 (Source: IMF, Direction of Trade Statistics)

The assumption of constant internal export and import shares is not confirmed by the plots in figure 4. Yet, one can show that, under the weaker and more realistic assumption of a stationary internal export and import share, a country A’s debt-to-GDP ratio has a time-invariant mean if and only if a country B’s debt-to-GDP ratio has a time-invariant mean, given that all other countries’ debt-to-GDP ratios are stationary. Hence, it is a sufficient condition for the symmetry of mean-reversion but not for the symmetry of stationarity (as stated in Proposition 1). The assumption of constant shares also ensures the latter as it additionally implies that a country A’s debt-to-GDP ratio has time-invariant autocovariances if and only if a country B’s debt-to-GDP ratio has time-invariant autocovariances, given that all other countries’s debt-to-GDP ratios are stationary.

In sum, there seems to be evidence that the German net asset accumulation and the Southern net debt accumulation are, to some extent, two sides of the same coin. Yet, some caution is advised when interpreting the symmetry of unbounded net asset and net debt accumulation relative to GDP as these processes may be partly driven by diverging GDP growth rates.
Figure 5: The relationship between the memory of the external debt-to-GDP ratio and real effective exchange rate flexibility from 1975:1 to 2009:4

5.3 Non-parametric unit root tests

Similar to the above analysis of the relation between the responsiveness of net exports to external debt and exchange rate flexibility, we analyze how the memory of the debt series varies with the flexibility of the real exchange rate regime. Hence, we estimate

$$\Delta b_{i,t} = \bar{b}_i + (f_i(v_{i,t})(\rho_i - 1)b_{i,t-1} + \varepsilon_{i,t}$$

where we use a smoothing function $f(\cdot)$ in the real effective exchange rate volatility $v_{i,t}$.

The auto-regressive coefficient as a function of the exchange rate volatility is plotted in figure 5 for the North excluding Germany and the South including Germany. We find a similar result as above. In the North, the adjustment of the debt-to-GDP ratio to a long-run mean seems to accelerate with decreasing exchange rate volatility. In the South and Germany, however, decreasing real exchange rate flexibility is accompanied by a higher persistence of current account imbalances. This, once again, suggests that the introduction of the EMU affected the North and the South inversely. It seems to have reinforced the external imbalances between Germany and the South of Europe.

6 Concluding remarks

In this paper, we sought to assess empirically whether the growing current account imbalances in EMU countries are sustainable and whether the rise in those imbalances may be

\(^{25}\text{Note that for Germany alone we also find an inverse relationship between } \rho \text{ and } v.\)
associated with the reduction of exchange rate flexibility resulting from the introduction of the Euro.

We outlined a simple stochastic model of inter-temporal trade and derived the transversality condition (TC) and the inter-temporal budget constraint (IBC) whose validity we take as the condition for sustainability. Following Bohn (1995, 1998), we derive a simple testable condition sufficient (but not necessary) for the TC to hold: the response of the net exports to a one-unit change in external debt has to be positive. However, the validity of the TC is a very weak criteria for assessing debt sustainability. For this reason, we alternatively used a more operational criteria for sustainability which requires the debt-to-GDP ratio to be mean reverting. With this, we follow Bohn (2007) who argued that unbounded debt expansion relative to GDP cannot be sustainable from a practical perspective.

Using parametric as well as non-parametric estimation techniques we tested for sustainability and operational sustainability of external debt for ten European countries from 1975 to 2009: Germany (DE), France (FR), Finland (FN), Belgium (BG), the Netherlands (NL), Austria (AT), Italy (IT), Spain (ES), Portugal (PT) and Greece (GR). Using an error correction specification we estimated the long-run response of the net exports-GDP ratio to the debt-to-GDP ratio for different groups of countries and sub-periods. We found for the period prior to the implementation of the convergence criteria in 1997 that, on average over all countries, the external debt accumulation could be considered as sustainable. The trade adjustment mechanism seem to have avoided persistent imbalances in the current account prior to the introduction of the Euro. However, the response coefficient seems to have become negative in the subsequent period implying that there is no evidence that debt accumulation has been sustainable in this period. This finding is consistent with the view that the introduction of the Euro may have impeded some of the forces adjusting the current accounts. Furthermore, we find that debt accumulation could be considered as sustainable over the entire sample period only for the countries with low debt. Robustness checks which applied a different estimation strategy seem to confirm these findings. Further, the non-parametric estimation of the response coefficient reveals that it has been mainly countries in the South which seem to have a decreasing reaction coefficient since the introduction of the Euro convergence criteria. For the South of Europe, we find a proportional relationship between the reaction coefficient and real exchange rate flexibility which is consistent with the hypothesis that the EMU reinforced current account imbalances.

The analysis on the basis of the operational sustainability criteria reveals similar results. The Breitung panel unit root test indicates stationarity of the debt series on average over the whole sample period. The same holds for the period before the EMU implementation. Thereafter the unit root hypothesis cannot be reject anymore indicating that the current accounts became operationally unsustainable. Here, Italy, Spain, Portugal, Greece on the
one hand and Germany on the other, all of whom had external debt-to-GDP ratios deviating enormously from the mean, seem to contribute to operational unsustainability. While the unit root hypothesis cannot be rejected for a group consisting of these countries, it can be rejected for the others. Note, however, that this finding has to be interpreted with care as the operational sustainability criteria presumes that GDP growth rates do not diverge too much between countries as well as that each country’s shares of EMU exports and EMU imports are similar and stable over time. Further, the non-parametric estimations of the auto-regressive coefficients of the debt-to-GDP ratios reveal a reduction in the speed of mean-reversion in the Southern countries including Germany after the implementation of the convergence criteria. For these countries, we find an inverse relationship between the persistence of imbalances and the degree of exchange rate flexibility.

Our findings suggest that the growing imbalances among EMU countries cannot be sufficiently explained by rising capital market integration within the Euro Area – a view put forward by Blanchard and Giavazzi (2002) – and are therefore a serious policy issue. The EMU eliminated the nominal exchange rate mechanism and the common monetary policy aiming at price stability reduced the flexibility of inflationary adjustment. The Stability and Growth Pact and its rather inflexible requirements for national economic policy appears sub-optimal for monetary unions with unevenly developing economies. Given the low labor mobility between European countries, we therefore conclude that policy measures need to be implemented aiming at reducing current account imbalances.

Although the literature as well as the public discourse diverge regarding the question whether adjustment should take place in the surplus or deficit countries, there seems to prevail a broad consensus on core requirements to reduce current account deficits: First, the competitiveness of deficit countries needs to be increased. While this may be achieved by both expansionary wage policy in the surplus countries and wage cuts in the deficit countries, the benefits of coordinated wage policy within the Euro Area become evident. Also a coordinated management of investment flows may reduce an uneven development of productivity. Second, the divergent development of domestic demand among EMU countries needs to be somewhat reduced. Again coordinated wage policy as well as fiscal policy may allow for an active management of domestic demand developments and help reducing current account imbalances.
A Appendix

A.1 Proof of Proposition 1

Let $NX_t^i$ denote the net exports of country $i \in \{A,B\} \cup \mathcal{C}$ in period $t$. Let $Y_t^i$ denote GDP and $\gamma_t$ its growth rate which is assumed to be equal across all countries of the open economic area. Then we can define the net external debt-to-GDP ratio for country $i$, $b_t^i$, as

$$b_t^i \equiv \frac{-\sum_{\tau=0}^{t} NX_t^i}{\prod_{\tau=1}^{t}(1 + \gamma_{\tau})Y_0^i}$$

where $Y_0^i$ is the initial GDP. Note that part of this net external debt is matched by net external assets of the rest of the world, i.e. countries outside the economic area considered.

Let $1 - \lambda^i$ be the fraction of a country $i$’s exports to the rest of the world which we assume to be equal to the fraction of its imports from the rest of the world. We assume $\lambda^i$ to be constant and define

$$\hat{b}_t^i \equiv \frac{-\sum_{\tau=0}^{t} \lambda^iNX_t^i}{\prod_{\tau=1}^{t}(1 + \gamma_{\tau})Y_0^i}$$

as the relation between the part of a country $i$’s net external debt which is matched by the net external assets of countries within the economic area considered and its GDP.

Accounting implies for any period $t$ that $\lambda^A Nx_t^A + \lambda^B Nx_t^B + \sum_{j \in \mathcal{C}} \lambda^j Nx_t^j = 0$. Hence, summing up this equation over all periods $\tau = 0, \ldots, t$, dividing by $\prod_{\tau=1}^{t}(1 + \gamma_{\tau})$ and using (22) yields

$$\hat{b}_t^A Y_0^A + \hat{b}_t^B Y_0^B + \sum_{j \in \mathcal{C}} \hat{b}_t^j Y_0^j = 0$$

(23)

Note that $\hat{b}_t^i \sim I(k)$ with $i \in \{A,B\} \cup \mathcal{C}$ and $k \in \mathbb{N}^+$ if and only if $\hat{b}_t^i Y_0^j \sim I(k)$ since $Y_0^j$ is a constant. Similarly, $\hat{b}_t^i \sim I(k)$ with $i \in \{A,B\} \cup \mathcal{C}$ and $k \in \mathbb{N}^+$ if and only if $\hat{b}_t^i \sim I(k)$ since $\lambda^i$ is a constant.

Suppose $b_t^i \sim I(0) \forall i \in \mathcal{C}$. Then, (23) implies that $b_t^A \sim I(0)$ if and only if $b_t^B \sim I(0)$. 


References


